

under paragraph (d)(5)(i) of this section.

(ii) Engine shutdown during the required run-on demonstration specified in paragraph (d)(5) of this section.

(iii) The conditions specified in paragraph (b)(3) of this section.

(5) The following test schedule must be used:

(i) Ingestion followed by 1 minute without power lever movement.

(ii) Followed by 13 minutes at not less than 50 percent of maximum rated takeoff power or thrust.

(iii) Followed by 2 minutes between 30 and 35 percent of maximum rated takeoff power or thrust.

(iv) Followed by 1 minute with power or thrust increased from that set in paragraph (d)(5)(iii) of this section, by between 5 and 10 percent of maximum rated takeoff power or thrust.

(v) Followed by 2 minutes with power or thrust reduced from that set in paragraph (d)(5)(iv) of this section, by between 5 and 10 percent of maximum rated takeoff power or thrust.

(vi) Followed by a minimum of 1 minute at ground idle then engine shutdown. The durations specified are times at the defined conditions. Power lever movement between each condition will be 10 seconds or less, except that power lever movements allowed within paragraph (d)(5)(ii) of this section are not limited, and for setting power under paragraph (d)(5)(iii) of this section will be 30 seconds or less.

(6) Compliance with the large flocking bird ingestion requirements of this paragraph (d) may also be demonstrated by:

(i) Incorporating the requirements of paragraph (d)(4) and (d)(5) of this section, into the large single bird test demonstration specified in paragraph (b)(1) of this section; or

(ii) Use of an engine subassembly test at the ingestion conditions specified in paragraph (b)(1) of this section if:

(A) All components critical to complying with the requirements of paragraph (d) of this section are included in the subassembly test;

(B) The components of paragraph (d)(6)(ii)(A) of this section are installed in a representative engine for a run-on demonstration in accordance with paragraphs (d)(4) and (d)(5) of this section;

except that section (d)(5)(i) is deleted and section (d)(5)(ii) must be 14 minutes in duration after the engine is started and stabilized; and

(C) The dynamic effects that would have been experienced during a full engine ingestion test can be shown to be negligible with respect to meeting the requirements of paragraphs (d)(4) and (d)(5) of this section.

(7) Applicants must show that an unsafe condition will not result if any engine operating limit is exceeded during the run-on period.

TABLE 4 TO § 33.76—LARGE FLOCKING BIRD MASS AND WEIGHT

Engine inlet throat area (square meters/square inches)	Bird quantity	Bird mass and weight (kg (lbs))
A <2.50 (3875) .....	none	
2.50 (3875) ≤ A <3.50 (5425) .....	1	1.85 (4.08)
3.50 (5425) ≤ A <3.90 (6045) .....	1	2.10 (4.63)
3.90 (6045) ≤ A .....	1	2.50 (5.51)

[Doc. No. FAA-1998-4815, 65 FR 55854, Sept. 14, 2000, as amended by Amdt. 33-20, 68 FR 75391, Dec. 31, 2003; Amdt. 33-24, 72 FR 50868, Sept. 4, 2007; Amdt. 33-23, 72 FR 58974, Oct. 17, 2007]

### § 33.77 Foreign object ingestion—ice.

(a) Compliance with the requirements of this section must be demonstrated by engine ice ingestion test or by validated analysis showing equivalence of other means for demonstrating soft body damage tolerance.

(b) [Reserved]

(c) Ingestion of ice under the conditions of this section may not—

(1) Cause an immediate or ultimate unacceptable sustained power or thrust loss; or

(2) Require the engine to be shutdown.

(d) For an engine that incorporates a protection device, compliance with this section need not be demonstrated with respect to ice formed forward of the protection device if it is shown that—

(1) Such ice is of a size that will not pass through the protective device;

(2) The protective device will withstand the impact of the ice; and

(3) The ice stopped by the protective device will not obstruct the flow of induction air into the engine with a resultant sustained reduction in power or

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thrust greater than those values defined by paragraph (c) of this section.

(e) Compliance with the requirements of this section must be demonstrated by engine ice ingestion test under the following ingestion conditions or by validated analysis showing equivalence of other means for demonstrating soft body damage tolerance.

(1) The minimum ice quantity and dimensions will be established by the en-

gine size as defined in Table 1 of this section.

(2) The ingested ice dimensions are determined by linear interpolation between table values, and are based on the actual engine's inlet hilite area.

(3) The ingestion velocity will simulate ice from the inlet being sucked into the engine.

(4) Engine operation will be at the maximum cruise power or thrust unless lower power is more critical.

TABLE 1—MINIMUM ICE SLAB DIMENSIONS BASED ON ENGINE INLET SIZE

Engine Inlet Hilite area (sq. inch)	Thickness (inch)	Width (inch)	Length (inch)
0 .....	0.25	0	3.6
80 .....	0.25	6	3.6
300 .....	0.25	12	3.6
700 .....	0.25	12	4.8
2800 .....	0.35	12	8.5
5000 .....	0.43	12	11.0
7000 .....	0.50	12	12.7
7900 .....	0.50	12	13.4
9500 .....	0.50	12	14.6
11300 .....	0.50	12	15.9
13300 .....	0.50	12	17.1
16500 .....	0.5	12	18.9
20000 .....	0.5	12	20.0

[Doc. No. 16919, 49 FR 6852, Feb. 23, 1984, as amended by Amdt. 33–19, 63 FR 14798, Mar. 26, 1998; 63 FR 53278, Oct. 5, 1998; Amdt. 33–20, 65 FR 55856, Sept. 14, 2000; Amdt. 33–34, 79 FR 65537, Nov. 4, 2014]

§ 33.78 Rain and hail ingestion.

(a) *All engines.* (1) The ingestion of large hailstones (0.8 to 0.9 specific gravity) at the maximum true air speed, up to 15,000 feet (4,500 meters), associated with a representative aircraft operating in rough air, with the engine at maximum continuous power, may not cause unacceptable mechanical damage or unacceptable power or thrust loss after the ingestion, or require the engine to be shut down. One-half the number of hailstones shall be aimed randomly over the inlet face area and the other half aimed at the critical inlet face area. The hailstones shall be ingested in a rapid sequence to simulate a hailstone encounter and the number and size of the hailstones shall be determined as follows:

(i) One 1-inch (25 millimeters) diameter hailstone for engines with inlet areas of not more than 100 square inches (0.0645 square meters).

(ii) One 1-inch (25 millimeters) diameter and one 2-inch (50 millimeters) diameter hailstone for each 150 square inches (0.0968 square meters) of inlet area, or fraction thereof, for engines with inlet areas of more than 100 square inches (0.0645 square meters).

(2) In addition to complying with paragraph (a)(1) of this section and except as provided in paragraph (b) of this section, it must be shown that each engine is capable of acceptable operation throughout its specified operating envelope when subjected to sudden encounters with the certification standard concentrations of rain and hail, as defined in appendix B to this part. Acceptable engine operation precludes flameout, run down, continued or non-recoverable surge or stall, or loss of acceleration and deceleration capability, during any three minute continuous period in rain and during any 30 second continuous period in hail. It must also be shown after the ingestion that there is no unacceptable mechanical damage, unacceptable power or thrust loss, or other adverse engine anomalies.